The Thesis Committee for Scott Adams Moorhead
Certifies that this is the approved version of the following thesis:

Hydraulic Fracturing and Federalism: How Regional Needs Should Drive Regulatory Oversight, with Texas as Case Study

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor:

Charles Groat

Charles Kreitler

Hydraulic Fracturing and Federalism: How Regional Needs Should Drive Regulatory Oversight, with Texas as Case Study

by

Scott Adams Moorhead, BA

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

The University of Texas at Austin

May 2012

Dedication

For my Dad, Edwin Terry Moorhead.

Acknowledgements

In great appreciation of my professors at the University of Texas, particularly Dr. Charles Kreitler, who went out of his way to counsel, teach and encourage. To Dr. Kent Butler—I had really hoped to work with you, and you were an extraordinary man, and I will not forget you. To Dr. Jack Sharp for direction and excellent teaching. To Dr. Charles Groat for shepherding this important program and for your efforts on my behalf. To Dr. Suzanne Pierce for allowing me to collaborate with you. To Dennis Trombatore, whose work and efforts are immeasurable and irreplaceable. Thanks to Heidi, Huck, the Menagerie, Dr. William J. Bryan, Governor Ben Barnes, my parents and family, good luck and great friends. Lastly, to John A. and Katherine G. Jackson for creating opportunities for so many students.

Abstract

Hydraulic Fracturing and Federalism: How Regional Needs Should Drive Regulatory Oversight, with Texas as Case Study

by

Scott Moorhead, MA

The University of Texas at Austin, 2012

SUPERVISOR: Charles Groat

Hydraulic fracturing of shale has combined traditional oil and gas industry techniques to create significant new reserves in the United States. Poor science, incomplete media coverage and politicization of the issues threaten broad understanding of issues of genuine concern while overstating others. The Environmental Protection Agency should focus on science-based regulation prior to enumerating new rules and should continue to cede primacy to the states where traditional regimes have proven successful in regulating oil and gas. The most critical issues associated with hydraulic fracturing tend to be regional and predicated on local hydrogeology. Surface water disposal and emissions standards need revision and strengthening. Scarce resources should be dedicated to better understanding regional water availability and to heightened awareness of the energy-water nexus.

Table of Contents

LIST OF FIGURES

Chapter One: Introduction

1.1 Background Issues

Culling recent reports on hydraulic fracturing, the seminal conclusion is the discussion of how to safely harness the technology has been misguided at best and disingenuously false at worst. Though controversies surrounding hydraulic fracturing for shale gas and oil (also "fracking," "fraccing," "fracing" or "HF") have centered on concerns like water contamination, water use and seismicity issues, to name a few flashpoints, our understanding of the science and technology is far more mature than popular reports might suggest. Lesser-known issues such as implications of widespread water use may be early-stage, based on disparate data that has yet to be studied holistically. Reanimation over federal and state sovereignty in recent years, evidenced by the rise of the Tea Party and manifest in movements like Occupy Wall Street, has also found an updated poster child: fracking is an ideal proxy for ideological disagreements over sovereignty and the modern-day meaning of federalism. Though "primacy" issues are not new fights, particularly in the hydrocarbon industry, fracking appears to have touched a nerve. Some consider it to be an appropriate successor in the line of great innovation in domestic fossil fuel production. Others view it as a last grasp at hegemony by an industry whose causal ties to anthropogenic climate change are unacceptable. Still another contingent may see fracking combined with directional drilling as the means to the last great hope for compromise between scalability and environmental sustainability, a means to domestic fuels that will aid in protecting our security interests while bridging to cleaner energy. Finally, a far more familiar incentive is in play: domestic oil and gas reserves are suddenly plentiful once more, and a great deal of money is at stake.

Figure 1.1. A well mid-frac. There is another vertical well roughly 20 feet out of frame to the right, emphasizing the significance of the breakthrough of directional drilling: the production team is able to consolidate equipment, materials and personnel in a relatively small area and simply migrate from one pad to another. The lateral wells deep below will then spread out in different directions, allowing the producer to have several miles of horizontal wells from just a couple of vertical entries, greatly reducing the surface footprint of the operation. Photo by author.

At Congress' behest, the EPA (among other regulatory bodies) is in the process of a large-scale data collection and study centered on the exploration industry with a principal aim to "elucidate the relationship, if any, between hydraulic fracturing and drinking water resources", but will only release preliminary data later in 2012, with a full report expected in 2014 (though the study outline was released in November 2011, behind schedule, which may portend delays on deliverable dates). The endeavor will be a collaborative effort, aided by the Department of Energy, the US Geological Survey, the US Army Corps of Engineers and the Pennsylvania Geological Survey. In an election year, there will be considerable pressure from the White House to blunt or delay any findings that could complicate the electoral landscape, particularly because negative findings could have consequences for several swing states that are critical for the Obama reelection (Pennsylvania, Colorado, Ohio, and to a lesser extent, Virginia, to name a few).

Currently, much of the best data is scattered across industry or buried in local and state levels. There is little formal apparatus in place to aide large-scale assembly and evaluation (Nicot 2012). To boot, industry is often suspicious of any oversight, much less at the federal level, and is still in the process of understanding the resource considerations involved in the explosion of shale gas. In other words, the big picture with respect to water availability, water use and other concerns is still coming into focus. A core misconception tends to be that those directly involved in exploration have a static and complete understanding of all peripheral considerations attendant to practices. They do not. Like any nascent industry, best and most efficient practices evolve over time. Put another way, real-time practices are imperfect. They then get evaluated, codified, or changed according to whether the economics work. Like any operation where hourly costs runs upwards of $40,000 per hour for rig time (Moorhead site visit), activity stoppages cause huge financial losses, which makes calibration in real time potentially costly. For this reason, significant additional research is needed, and yet the local, state and federal agencies charged with understanding and regulating the core issues remain underfunded. Simultaneously, these agencies operate under doubts from all sides that findings will be appropriate, either biased toward industry or environmentalists.

1.2 Study aims

The aim of this study is to focus on core issues: 1) to briefly review potential dangers associated with hydraulic fracturing; 2) to show how risks are properly and adequately addressed by the existing regulatory framework between the states and the federal government; 3) to discuss the sovereignty issues currently at the forefront of the discussion; and 4) to direct attention toward more compelling issues like local water availability. I argue that the nature of the industry and the potential hazards attendant to fracking suggest local regulation is superior to broad federal-driven oversight, with a couple of key exceptions. Broadly speaking, however, today's science does not indicate that recent innovations have exceeded the bandwidth of existing regulatory regimes or interrelationships to properly regulate the industry.

Chapter Two: Concerns over hydraulic fracturing

2.1 Lack of Vocabulary Impedes Progress

The ease of distributing uncorroborated, unsubstantiated data via modern media has plagued public understanding of fracking from the outset. Industry, the public good, and government attempts at oversight alike have suffered. Even now, no commonly accepted definition for "fracking" has steadfastly emerged. Pains to differentiate hydraulic fracturing of gas and oil plays (a "play" is an industry term that describes a potentially hydrocarbon-rich zone) are uncommon, and "fracking" as often indicates the actual fracturing of the rock as it does the cradle-to-grave process of drilling, casing, hydraulic fracturing, retrieval and waste disposal (or some combination thereof), leading many to make the seemingly basic point to distinguish production from the actual frac process (Buchele 2011). Similar instances of confusion have attended a number of terms of art that are widespread in the petroengineering industry, but unfamiliar to hydrologists and water managers—and vice versa. Clarity is of utmost import, as experts of all kinds seek complete data on hot button issues like hydrological accounting, wastewater disposal and groundwater contamination. Simple measures like common language and a full understanding of the process, combined with more robust data like background logs, water use data, chemical disclosure and other means will go a long way toward solving these issues. Without a common parlance, mistakes and misconceptions are inevitable and will be very costly. It is already acknowledged that the lack of shared knowledge is thwarting the pace of development and technology transfer (Stone 2012).

2.2 Growth of Industry

The idiomatic muddle emerges because industry growth since 2006 or so has been simply astounding. The US Energy Information Administration reports that recoverable gas resources have doubled in 2011 alone, and that by 2035, 45% of our nation's natural gas will come from shale gas extraction made possible by HF (Figure 2.2).

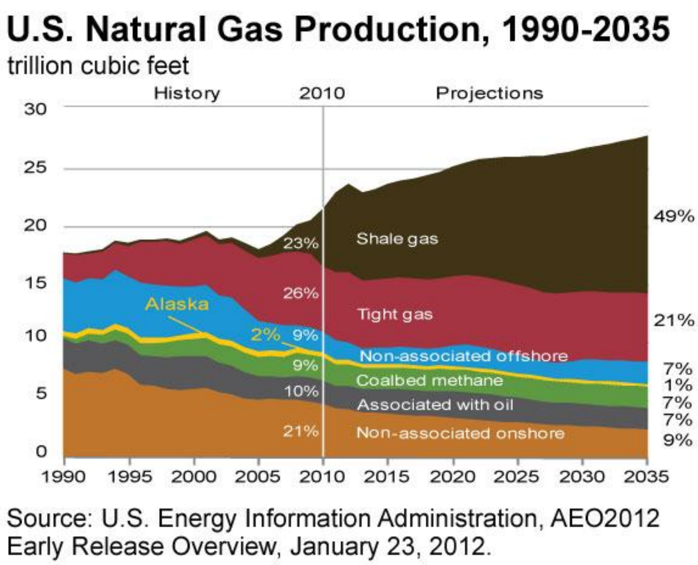


Figure 2.2 Projected natural gas production from the US, 1990-2035. Hydraulic fracturing combined with directional drilling makes possible commercial exploration for these unconventional reserves.

Such rapid growth causes gaps in shared knowledge, and also brings together disciplines and their practitioners in new and sometimes unforeseen ways. During the author's site visit to a drilling operation at an Eagle Ford oil and gas lease, several water managers spoke with one of the crew overseeing a ten-day frack job. Talk turned to water scarcity and the need for recycling, but managers and oil hands could reach no consensus on a definition on brackish groundwater; that is, their total dissolved solids (TDS) counts were distinctly different. One person's brine was another person's brackish (and potentially usable) source, again underscoring the need for a *lingua franca.* Greater information exchange across disciplines will mitigate the problem, as water recycling becomes more commonplace and water managers become increasingly familiar with volumes necessary for energy exploration and development.

Because of technical and geological variations regionally and even within a given play, imprecise labeling of different parts of the process exposes regulatory agencies and the public in a negative way. Stakeholders may concentrate on parts of the process where know-how is already mature, while ignoring or underemphasizing more immediate concerns that are more deserving of scrutiny.

2.3 EPA Intervention

Recent EPA findings and subsequent media attention bears this out. On December 8, 2011, the EPA made public the linkage between hydraulic fracturing and groundwater contamination at Pavillion near Cheyenne, Wyoming. Critical headlines decried the link between hydraulic fracturing and groundwater contamination, while the actual report suggests that the frac process had no bearing on the water, and practices at the site were unorthodox and distinctly different than shale plays in Texas, Pennsylvania and New York (Fuel Fix January 13, 2012). It is alleged to be the first documented instance in which groundwater contamination occurred as a direct result of the hydraulic fracturing process itself, rather than subsequent disposal of water or storage of water. Many details of the case were unusual, however, not only because they reveal significant potential negligence by the exploration company (who happens to be Canadian), but also because they reflect practices that are not widespread—shallow vertical fracturing in a sand aquifer, for example, and storage of flowback in unprotected reservoirs near water wells. While evidence may suggest malfeasance, a kneejerk reaction without contextualizing the issue will be costly for industry, policymakers and consumers.

There is no better example of taking premature action without corroborating science than the Range Resources case that unfolded over the last year near Dallas, Texas. In late 2010, EPA's Region Six office, acting under auspices of the Safe Drinking Water Act (SDWA), issued an emergency order to Range Resources to halt frac operations in the Barnett Shale in Parker County, Texas. Citing a local landowner's concern that the nearby frac operations had contaminated his well water with methane, and in direct opposition to the state Railroad Commission, who had reviewed the technical data and found no evidence of contamination as a result of the fracking operation, EPA sustained a 15-month-long emergency order. Technical data reviewed by multiple experts showed that methane found in the homeowner's well was methane from a shallower formation that had not been perforated by Range (Kreitler 2011, Riley 2011). In a telling maneuver, EPA quietly lifted the emergency order late Friday on March 30, 2012, indicating it also concluded that no contamination had occurred. Though EPA made no admission of a reversal as to the source of the thermogenic gas, Friday press releases are commonplace when trying to blunt potential media attention. Range has agreed to sample water for the next year at twenty private wells near the site (Schlacter 2012). The episode was a stark reminder that politicizing these issues from any angle prior to discovery of strong science and a broad understanding of the industry will be a mistake. The current rift between EPA and industry can be attributed in large part to a true lack of coordination and communication between the agency and industry leaders. There has been far too little shared discourse between parties to expect strong information sharing to have emerged to date.

2.4 Contamination Concerns

To date, no studies exist to tie the process of hydraulic fracturing to groundwater contamination. Rather, contamination issues appear to involve the more traditional parts of the production process that are commonplace in oil and gas exploration, such as well casing, flowback control, and disposal of wastewater. Former Pennsylvania

Department of Environmental Protection Secretary John Hanger recently gave an interview in the New York Post:

> Prior to the Marcellus [exploitation], there have probably been 50 to 150 private water wells, out of more than a million in the state, that have had methane contamination as a result of mistakes in the drilling process — but that has nothing to do with fracking…Some in the industry deny that it ever happens, and that is false... But frack fluids returning from depth, from 5,000 to 8,000 feet under the ground, to contaminate an aquifer? When the industry says that's never happened, that has in fact *never happened*. And fracking has had no impact on the public water supply.
>
> (Williamson 2012)

2.4.1 Compelling physical constraints suggest local control

Physics and rock dynamics suggest that fracking in deep shale is so geologically isolated from shallow aquifers that it is impossible to surmise that fracking fluid could migrate from deep laterals through several thousand feet of effectively impermeable rock to contaminate an aquifer (figure 2.4).

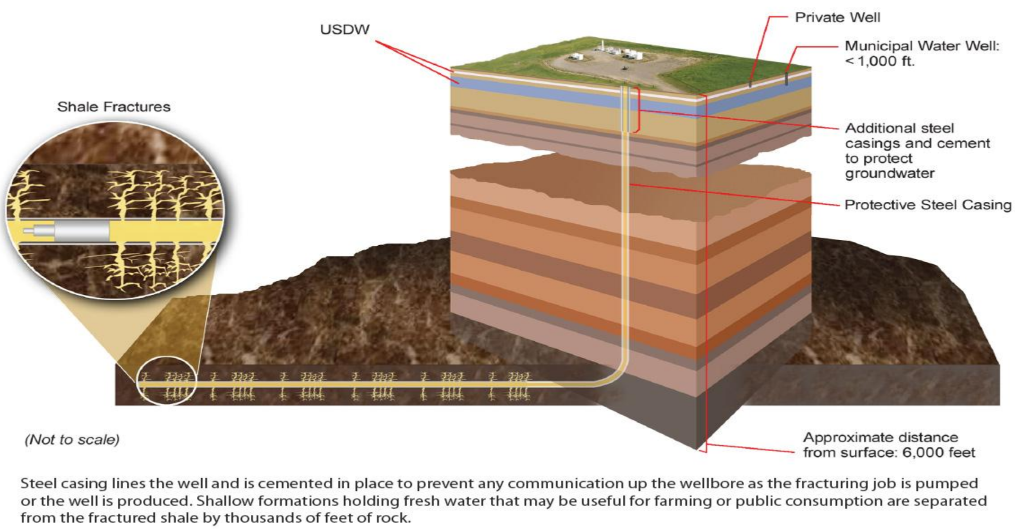


Figure 2.4. Schematic of a fracked well and adjacent water well. Not to scale. Source: Source: US Department of Energy, Fossil Energy Web, http://www.fossil.energy.gov/images/programs/oilgas/hydraulic_fracturing_large.jpg

An emerging consensus believes that the critical avenues for environmental problems largely arise at the surface, where transportation and storage of flowback, heavy traffic, emissions levels and other sorts of activity-related issues can arise (Groat 2012). These are critical acknowledgements because these sorts of activities are already heavily and predictably regulated in the traditional oil and gas industry through existing agreements between states and the EPA. The novelty of the shale gas boom lies in the sheer magnitude of activity and the unavoidable pressures that the volume has created: in terms of trucks on the road, rigs in use, water volumes injected and returned to the surface, for example. It is not so much that new issues demand new regulation as much as there is more and more activity of a familiar kind that must be monitored.

Contaminated flowback waters and emissions leap out as areas where EPA may have a strong interest. Yet local geology is a critical factor in wastewater disposal because it circumscribes the method of disposal. For this reason, practices like surface water disposal have traditionally been more common in the Marcellus play in Pennsylvania and New York than in places like Texas, where geologies permit the hydraulic isolation needed for deep well injection. Importantly, flowback and wastewater disposal have been a concern for industry and regulators long before the advent of widespread HF, and so mechanisms to govern these practices have been in place for decades. The degree to which geology and hydrogeology can vary from locale to locale suggests that regulatory regimes should continue to place a premium on flexibility.

Flowback rates offer a strong example. In the Eagle Ford Shale, flowback rates are only up to 10% at a given well (Moorhead, Ely) commensurate with a DOE-based report that the Eagle Ford recovery rate is "almost no(ne)" compared to the Marcellus Shale, where flowback volumes range from 20-40% of the injected volume. (SEAB ninety-day report). Nevertheless, estimates vary widely and are region-specific, yielding ranges of 15-80% in some reports (Rahm 2011), suggesting that more detailed regional studies are necessary to truly understand nuances among locales. Nevertheless, the wide fluctuation in flowback alters disposal and availability needs from place to place; grossly, there is a lesser need for flowback disposal on a per well basis in the

Eagle Ford than in the Marcellus, for example, so best practices will vary. Recycling is comparatively less important in the Eagle Ford than is water availability, and safe disposal and recycling are more critical by comparison.

Chapter Three: The Existing Regulatory Regime: States Have Primacy

3.1 Purpose of regulation

A presumed aim of regulation is to exact a civic protection sufficient to defend the public health and good while maintaining this barrier at the lowest cost to producers, society and government; in other words, to optimize benefits while minimizing costs, and our politics are presumably constructed around how and through whom to achieve these aims. A subsequent question concerns the proper level of government need to achieve that optimization under constitutional grounds, while ensuring that no level of government assumes oversight beyond the point it can reasonably and economically enact its role to create and enforce policy. In the energy industry especially, balancing these demands can be vexing. Part of the vexation stems from the sheer volume of producers and the complexity of upstream and downstream operations. Significant, comprehensive data collection is an expensive and time consuming task.

3.2 EPA Oversight

The existing apparatus for dealing with the more salient issues that could threaten groundwater—well casing, deep well injection--are largely already in place, with some key exceptions. The aforementioned apparatus centers on the balance of primacy ceded to the state by EPA upon mutual agreement.

3.2.1 UIC Program

Under the EPA's underground injection control (UIC) program, state UIC programs have primary regulatory and enforcement authority once those programs have received EPA approval (EPA UIC Primacy). States may apply for primacy dealing with parts or all of their respective waste injection programs, which are defined by EPA, and if states do not meet requirements, or elect to turn over control to EPA, one of the EPA's ten regional offices assumes responsibility. Ten states currently cede all injection oversight to the EPA, while seven more share joint responsibility. The remaining majority have adopted and enacted their own EPA-approved state programs (figure 3.2).

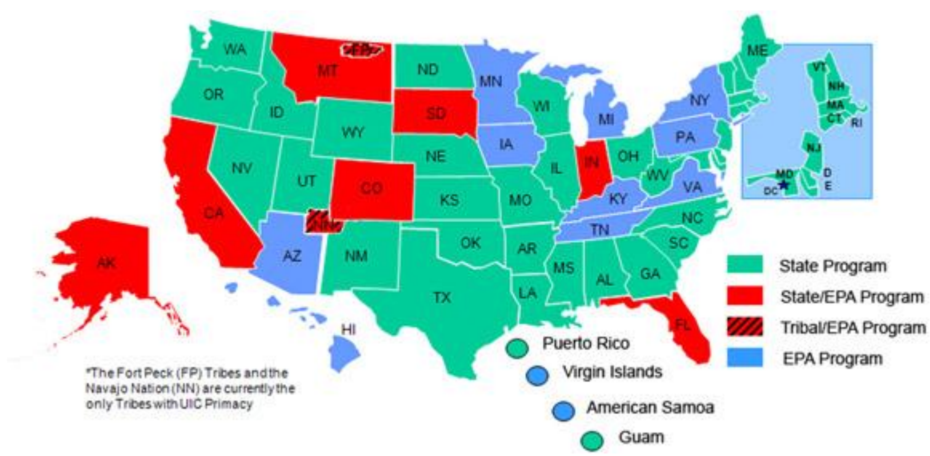


Figure 3.2. EPA UIC Primacy. EPA has delegated primacy for all wastewater injection well classes to 33 states and 3 territories; it shares responsibility with 7 states (i.e., EPA has authority over some classes and the state has authority for others). http://water.epa.gov/type/groundwater/uic/Primacy.cfm

Discussion of EPA involvement in hydraulic fracturing requires, once again, precision of nomenclature. EPA intervention in the early stages of the actual fracking seems unnecessary, though there is some thought that EPA may create broad rules for constituent disclosure. The available avenues to do so vary in legal strength and scope.

3.2.2 History of EPA Involvement

As far back as 1997, EPA was urged to regulate fracking fluids under Safe Drinking Water Act (SDWA). At the US Court of Appeals' behest, EPA conducted a study of hydraulic fracturing in coal bed methane that yielded a 2004 decision to abstain from regulating the practice, and further exempted the technique from future study (Rahm 2011). The National Energy Policy Act of 2005 then expressly exempted HF from regulation, in spite of opposition. Commonly known as the "Halliburton loophole," the exemption does not allow EPA oversight of injection of "the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" (though wells using diesel fuel must be permitted). Per the regulation, "state oil and gas agencies may have additional regulations for hydraulic fracturing. (EPA Web, About EPA: What we do)

3.2.3 Constituent Disclosure

Many states do have disclosure rules in place. It is virtually certain that more states will pass rules and/or laws in the near future. Some of the urgency is attributable to a maturing understanding of potential hazards, and some is due to industry and state alarm that best practices should be established locally to obviate the need for EPA to intervene. According to the National Conference of State Legislatures, by mid-summer 2011, eight states had already considered legislation to require disclosure of fracking fluids. Though Texas is among the only states to have disclosure language written by statute (others have state regulations), others, like Wyoming, also boast formidable databases to track things like background chemistry (Engle interview). The Texas law requires drillers to publicly post hydraulic fracturing fluid constituents, though it does allow them to withhold limited information that would presumably place them at a competitive disadvantage. The law is quite similar to those in other states, which reflect a general insistence on disclosure, though some proposals have come under fire for allowing industry to withhold even a small amount of information, or for only disclosing certain formulae to regulatory agencies or first responders. On February 1, 2012, the Texas law went into effect. Wells in operation before February 1, 2012 remain under voluntary disclosure; only wells with an initial drilling permit after February 1, 2012 will have to disclose on a public website called FracFocus (StateImpact Dec 16, 2011) (Figure 3.2a).

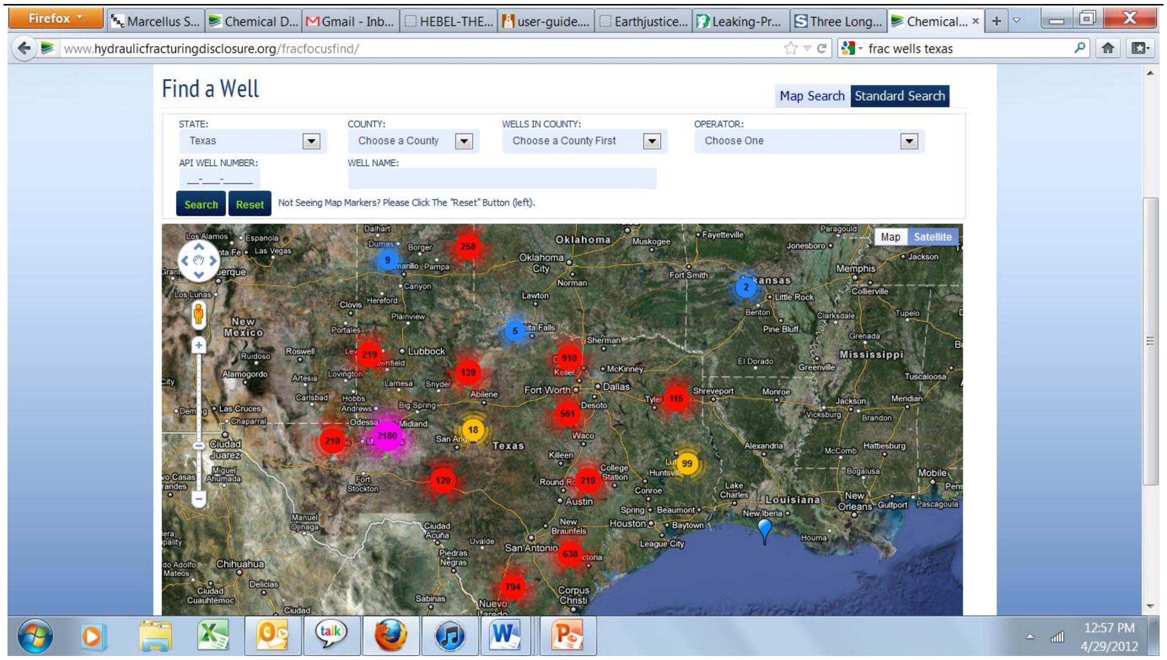


Figure 3.2a Screen Grab from www.fracfocus.org website. The website is searchable by different fields; the shot above shows well concentrations in Texas. The zoom feature on the left side of the screen allows the user to more precisely define the geographic window of search. User can also search by well number, county, well name or operator, among other fields. Photo by author.

FracFocus also features some Bureau of Land Management (BLM) wells on Federally-held lands; this is a recent development initiated by Secretary of the Interior Ken Salazar. Though EPA has yet to formally engage on this issue, there seem to be pressure points. The BTEX compounds sometimes used in fracking—benzene, toluene, xylene and ethylbenzene—are subject to regulation under SDWA and CAA, and were a major focus of the Waxman Committee Report, which many regard as the most focused and comprehensive effort to date to disclose possible frack fluid constituents (Waxman 2011, Groat et al 2012).

Under the Clean Water Act (CWA), EPA may intercede in other areas of fracking operations, albeit indirectly, requiring storm water management plans (SWMPs) to regulate water quality at sites during periods of heavy precipitation (Groat 2012). More directly, under primacy laws, states and/or EPA retain authority under CWA to regulate surface discharge of produced waters from hydraulic fracturing operations under the National Pollutant Discharge Elimination System (NPDES) permit program (EPA Natural Gas Extraction Web). Discharge into class II injection wells allows states to discharge of the produced waters according to their EPA-approved state UIC program (figure 3.2b). These programs are sanctioned under SDWA with the explicit goal of protecting underground drinking water sources (USDWs), which include any waters of less than 10,000 TDS (EPA Web Guidance for determination). The UIC program is over thirty years old and benefits from third-party mediators like the groundwater protection council, a national association of state groundwater agencies who assists EPA with brokering among the states (EPA UIC Web).

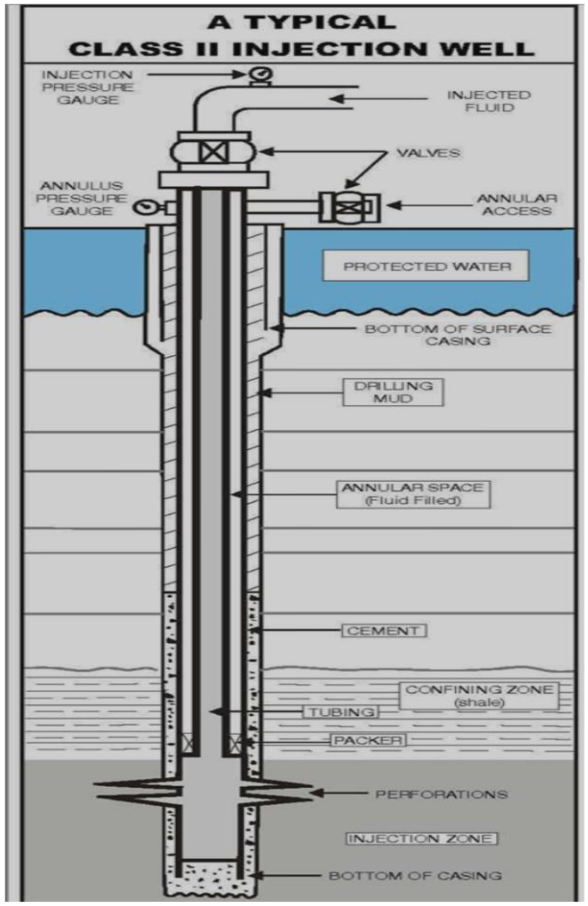


Figure 3.2b. A Class II Injection well. Source: TX RR Commission Web,

http://www.rrc.state.tx.us/about/faqs/images/injectionwelllg.jpg

---

Surface water disposal is critically different from deep well injection, generally speaking, because the water is not effectively removed from the hydrologic cycle, and because the existing laws, written before the frack boom, have proven insufficient. Historically, those states with surface water disposal needs have been slow to adopt efficacious means of treatment. The most high-profile of these is Pennsylvania. Early in the shale boom, produced flowback was frequently disposed of in Pennsylvania's surface waterways and processed by wastewater treatment plants. These disposals were likely legal under NPDES, which requires that prior to surface disposal effluent is treated prior to disposal. Problematically, however, these wastewater facilities lack the infrastructure to properly remove heavy metals, NORMS, and other compounds used for the frack or found naturally in formation. Interestingly, Pennsylvania is one of the seven states whose disposal program has been ceded entirely to EPA (figure 2).

Despite its legality, surface disposal is growing less common. Producers in the Marcellus have moved away from surface water disposal in favor of transporting produced waters to states like Ohio, where deep well injection is more common. Though its practice is diminishing, and despite collaborations between industry and state regulators on recycling programs and treatment plans, the reality is that the potential cross-state impact via surface water systems, i.e. the Chesapeake Bay estuary, makes this a major issue for EPA. More stringent requirements for flowback water processing prior to surface disposal would be the most basic prerequisite for bolstering regulations. Whether this appears in more stringent recycling requirements, additional treatment to remove constituents added during the frack or an outright ban on surface water disposals remains to be seen. In any case, surface disposal of flowback appears to be one of the key areas where EPA can and should more greatly restrict activities; it is key to point out, however, that in so doing there would be no need to upend the primacy model. Rather, more stringent regulations can be imposed that would still allow states to institute equally or more rigorous requirements. This allows states with mature deep well injection programs to continue with practices that history demonstrates are safe, while requiring those states with less mature industries to advance safe practices under the guiding hand of an EPA stipulation.

3.3 Approach to oversight

The argument for more rigorous oversight by the EPA is centered on the same principles that suggest its involvement need be comprehensive but moderated: namely, that there is extraordinary disparity between the states in terms of the maturity of the industry and the subsequent sophistication of regulatory regimes charged with local oversight. Shale gas is currently produced in 22 of the 50 states (Nicot 2012). States with long-standing oil and gas industries, like Texas, have developed methods and expertise that put them at the fore of the oil and gas frontier. History-rich states like Texas are highly concerned that networks that took generations to create—whether between industry and communities or industry and regulators—will be undermined by federal intervention pinned to standards that don't quite map onto local practices. Arguments that standards will be unnecessarily rigid or complex, and predicated on realities that occur elsewhere, are common.

3.3.1 Industry-regulatory conflicts

A common rebuttal is that state regulatory authorities in traditional oil and gas producing states have become too cozy with industry. There is merit to this counter. For one, conflicts of interest may predominate where regulators and industry have extended histories. Significant concerns arose in the aftermath of the Macondo Deepwater Horizon tragedy, suggesting that officials charged with oversight were overly friendly with the subjects of their reviews and that some shared relationships were overly and overtly transactional. These same kinds of charges have been leveled at institutions such as Texas' Railroad Commission and The Texas Commission of Environmental Quality (TCEQ), who bears responsibility for water quality parameters and pollution control. (Railroad Commission Web). Ultimately, however, there must be discourse and familiarity between industry and regulatory regimes regardless of the level of oversight. Cooperation between industry and regulatory authorities should not be tantamount to collusion. Furthermore, it seems unlikely that state level officials are somehow more exposed to potential conflicts of interest than federal officials, or that either industry or the environmental lobby wields more influence at a local level. The Supreme Court decision *Citizens United*, which made corporate donations to political action committees (PACs) legal (whereas before they were limited to paying administrative costs of those PACs), has opened the doors for significant contributions across federal, state and local elections, but it is unlikely that the federal government is less susceptible to corporate influence than a state-level agency. It is important to recognize that the EPA is appointment-based, as are many state regulatory authorities—

but the presumption that political donations do not have the power to influence government at any level- directly or indirectly is naïve at best. Furthermore, the variability among state governments and regulatory authorities—in effect, the presence of a state-by-state system of rules and regulations—may raise the costs of influence for interest groups because no two set of rules are exactly alike, and distributing money across several states may be more expensive than spending solely at the federal level in a targeted manner. This is not to say that any of the aforementioned actors are responsive to dollars, but rather that there does not seem to be a cogent argument that local regimes are more vulnerable to influence than larger ones.

Interestingly, there is some evidence suggesting that federally-led environmental policy and state-level enforcement may result in counterproductive results. A study conducted by Konisky (2009) found mixed effects, showing that state enforcement actually fell in the years after federal implementation of conservation and environmental justice legislation such as the Clean Water Act, the Resource Conservation and Recovery Act, and others. Rather, the data suggest officials may have muted or amplified enforcement actions to respond to changing economics at localized levels, i.e. within a county. His work found that states often targeted enforcement actions in higher poverty areas, but also decreased with rising unemployment, and there was no evidence to suggest that enforcement rose in areas with large poor, black or Hispanic populations (Konisky 2009). Surely the results are mixed and the mechanisms by which policy engagements succeed or fail are highly complex, but the work reinforces the notion that policy coupled with poor enforcement may result in negative impacts. It also fuels the argument that policymakers should concentrate on prudent encouragement of enterprises that foster economic growth within the bounds of environmental protectionism; that is, we should reconsider the potential positive impacts of local economic growth and whether it necessarily augers potential environmental justice issues. In other words, resource development does not necessarily engender environmental conflict.

Accordingly, a principal argument against increased involvement by EPA hinges on the concern that inadequate resources will plague a program of increased regulatory structure. In effect, more stringent rules will be difficult to monitor and enforce, which could cause costly delays in review or approvals processes, even for those who are in compliance. Under the EPA burden reduction (BR) initiative, specifically in the underground injection control (UIC) program, EPA itself admits that concerns remain that the initiative faces enforcement challenges due to funding; further oversight and responsibility will be a challenge for an agency already at risk of receiving significantly lower funding than requested in the latest budget.

Chapter Four: A Proper Balance

4.1 Environmental Federalism

The system of cooperative federalism dominates environmental law in the United States; that is, state and federal jurisdictions overlap and share joint, often overlapping responsibilities. Broadly, the founders were rightfully concerned with how issues of justice and fairness could be subsumed under the power of the majority. There was and still is a keen recognition that democratic processes do not always lead to the most just, fair or healthy outcomes. "Liberty may be endangered by the abuses of liberty as well as the abuses of power," James Madison wrote. The current regulatory regime from top to bottom, as well as industry, should remind themselves of this fact.

4.1.2 Overview of Activism

Starting in the 1970s, the federal government began to take a far more active role in environmental regulation, beginning with the creation of the EPA. EPA is a cabinet-ranked agency but is not a cabinet department, meaning it operates somewhat outside the sphere of influence of other cabinet departments, and is not in direct competition with other cabinet agencies; some argue this "outsider" status has given it greater autonomy than other cabinet-level agencies. Funding has always been an issue (Wellborn), even as its mission has expanded. The personnel and ideological changes in the executive branch over three decades have alternately contracted, expanded or modified how EPA has worked with the states and business. Reagan reduced EPA's authority during his time in office, proposing a laissez faire approach to intervention in industry; Bush I and Clinton are seen to have moderated it, giving more authority to the states. For a time, George W. Bush appeared willing to continue this trend, though increasingly his policies reverted to a more centralized, federally-driven strategy (Huque, Adelman). These characterizations are known as any number of permutations of federalism. Funding can be fickle: in 2010, EPA funding stood at \$10.3 billion—the largest in its history. Just two years later, the FY 2012 budget was \$8.973 billion—almost \$1.4 billion lower (and the enacted level was \$8.405B), while President Obama's 2013 request was even less, at 8.3B, suggesting the enacted figure will dip still lower. This is due to diminished government revenues but also to backlash against perceived federal overreaching. In response, the president (executive branch) asks for less money (so as not to be seen as expanding federal powers) and the legislative body (Congress) appeases political constituents by appropriating even less than requested (thus appearing to take a hard line against the president). One cannot underestimate how politics can affect regulatory regimes, and one might also surmise that the pendulum that swung toward that states under Bush and Clinton is nevertheless swinging back toward centralization under W. Bush and Obama.

4.2 Adaptive federalism v. matching principle

Macroexamination of these trends suggests a move toward what some call "adaptive" or "conjoint" federalism (Powers 2011, Huque 2010) which is sometimes attributed to the interstate commerce clause, which opened the door to federal intervention in state issues. Loosely put, adaptive federalism recommends a dynamic, agile exchange between federal and state governments to allow for maximizing efficiencies of oversight and cost while ensuring proper environmental protections. The idea serves as counterpoint to the matching principle, which recommends that a regulatory response to an environmental issue correlate level of government to the geographical magnitude of the problem. Accordingly, local government would handle issues of local concern, like a brownfield site, while the federal government might handle something like greenhouse gas emissions, which have cross-boundary impacts. As a problem grows in scope, the commensurate level of government intervenes accordingly. Herein, presumably, the regulating entity then fully internalizes the costs and benefits of the policy approach.

Resistance to the matching principle as a proper response hinges on the assertion that environmental issues are too complex to cleanly conform to a reductive scale. Namely, ecosystems are complex systems, ill-understood, and subject to laws and consequences that defy certain prediction. Under this reasoning, it is impossible to ably discern the limit at which a governmental intervention may have appropriately mitigated negative outcomes, so pinpointing a proper government actor is a misguided approach, or worse. This rationale sometimes seems to be given as a compelling reason to introduce federal intervention, under the auspices that one needs the largest umbrella possible to mitigate issues whose scope is beyond discernment.

4.3 Race-to-the-bottom

Adherence to the existing primacy structure between the states and EPA renders this concern largely moot. A common criticism in allowing states to develop distinct standards is that an excess laxity in standards could arise locally. Within a mobile industry, states and interest groups will then engage in a "race to the bottom," to court dollars and business, keeping enforcement and costs artificially and dangerously low. Such a scenario fails to materialize with most aspects of the hydraulic fracturing process, the two critical exceptions being surface water disposals and emissions of volatile organic compounds and other greenhouse gases (as they can transcend local boundaries or because the costs to transport them to less stringently-monitored states may not be prohibitive). Irrespective of state standards, exploration in the hydrocarbon industry follows money, not regulation, and static geology acts as the bank. Industry will not pass up productive leases because regulation is too stringent, and conversely, ease of exploration is meaningless if there is not significant oil or gas to be found. The market is driven by cost, and the costs of stringent or lax policy do not significantly affect decision-making when companies decided where to drill. Dr. Stephen Holditch of the Texas A&M Petroleum Department, sums it thusly: "little bitty things like (nominal) regulations will be overwhelmed by the geology. If they can't hit three to four to five times revenues, they wouldn't drill the well anyway. (The cost of regulation) is money off the bottom line, but it's not a difference–maker" (Holditch 2012).

4.4 Potential interventions

Focusing on EPA's past behavior is telling with respect to their current position and the wisdom of future intervention. In handling the Range case in Dallas and controversies in Dimock, Pennsylvania, and Pavillion, Wyoming, EPA appears to be testing the limits of enforcement capabilities based on the Safe Drinking Water Act (SDWA) and CERCLA. Some have noted the focus on naturally occurring radioactivity (NORMS) in wastewater, whose oversight is currently found at the state level and sometimes shared by two regulating authorities, as in Texas (Waeckerlin 2012, Groat 2012). The Toxic Substances Control Act (TSCA) 8, announced November 23, 2011, also may act as a vehicle for disclosure of constituents found in fracking fluid. EPA has accepted parts of a petition from the Watchdog group EarthJustice, saying there is "value in initiating a proposed rulemaking process using TSCA authorities to obtain data on chemical substances and mixtures used in hydraulic fracturing" (Serebrin 2011).

EPA also appears steeled to alter course from a policy of allowing voluntary disclosure by industry as a means of data provision and compliance. Past programs centered on voluntary disclosure have come under fire because of reporting biases. For example, EPA has long maintained an interest in a comprehensive coal ash disposal program, dating to the late 1970's. In recent years, in trying to formulate best practices and/or regulations, EPA has queried industry for data on the use of safeguards such as landfill liners to prevent groundwater leachate. Incomplete survey results, in addition to low response numbers, also suggest bias because respondents were more likely to employ best practices, offering a false impression of the scope of practices (EPA Hazardous and Solid Waste Rule). Such criticisms animate the argument that oversight of best practices requires more localized intervention—boots closer to, if not on, the ground. Unsurprisingly, then, the EPA's Office of Enforcement and Compliance Assurance has issued its draft guidance on the Fiscal Year 2013 enforcement program, and intends to "significantly cut back traditional federal enforcement strategies across all major federal environmental programs, and to eliminate the voluntary disclosure program long relied upon by industry to disclose violations discovered during compliance audits" (OECA 2012). A key question, of course, is how, or whether, it will fill the presumed regulatory vacuum.

Based on available evidence, it seems inevitable that EPA will conclusively engage in the discussion over hydraulic fracturing, if only nominally, particularly if President Obama is nominated for a second term. A continued Obama White House assures EPA of significant political cover even if both the House and Senate proceed under Republican control, particularly in a lame-duck second term where controversial decisions become less difficult to make. EPA's legitimate grounds for concern, in my view, centers on two issues: 1) cross-state emission from hydraulic fracturing operations, which should be subject to CAA and 2) surface disposal of formation waters, which may or may not be subject to race-to-the-bottom issues because of transport capabilities.

4.4.1 Green Completions

On the first point, on April 18, 2012, EPA issued its first-ever final rules on emissions from hydraulic fracturing operations under its CAA authority. The final regulation tasks operators with reducing emissions of volatile organic compounds (VOCs) by capturing 95% of the natural gas that is currently allowed to escape. These so-called "green completions" will be standard by 2015, allowing operators roughly two and a half years to phase in the technology (EPA Web, Oil and Natural Gas Air Pollution Standards). EPA estimates each completion may save roughly 10,800 Mcf of natural gas that would otherwise escape to the atmosphere, and that number may climb higher as technology improves (Harvey 2012). Though industry and watchdog groups dispute the costs of the process, the charge that producers will actually profit appears feasible, given that the technology is mature and that the API endorsed the rule. Indeed, independent studies show that producers have significant potential profits to make, which is one of the reasons EPA was able to push it through. It is important to note that four states (Texas, Wyoming, Montana and Colorado) already have green completion standards in place to varying degrees. (Harvey 2012).

4.4.2 Surface water disposal

With regard to more rigorous disposal rules, strides forward are still necessary; however, there is no reason why EPA cannot continue to cede primacy to the states in creation and execution of approved state implementation plans that are subject to EPA review. This is by no means a middling issue, but it has been heretofore addressed with NPDES (EPA Hydraulic Fracturing). The critical distinction with respect to surface water disposal is that the historical program guidelines appear insufficient to assure the safe removal of NORMS and heavy metals. Broadly speaking, there are many ways where EPA might assert its influence, exercise its budget, and foster the continued emergence of a stable industry that accomplishes the national aims of pursuing safe energy exploration without upending the existing model.

4.5 Best practices recommendations

A suite of recommendations for best practices might appear as follows:

- Federal standards for flowback treatment, storage and transportation are likely, but they should be flexible and subject to state primacy per EPA review. This leaves local regulatory structures in place and sovereign and allows them to leverage the knowhow, processes and personnel that would ensure no disruption to oversight. It allows states with unique geologies that allow for deep well injection to continue the practice, which has been in place for decades. It precludes the EPA from assuming additional costs burdens which it already appears incapable of assuming. Lastly, it allows EPA to address potential cross-state issues by requiring more rigorous standards for surface disposal, which though uncommon at this point still demands more stringent oversight. A reasonable analogue might be the SEC, responsible for regulating the financial industry. Many have pointed to the impossible task of regulating such a complex and giant industry with a staff of 4,000: the maxim that the best policy without capacity for enforcement is a needed reminder as officials contemplate significant, far-reaching and complex regulatory schemes. In the absence of easy answers, it is apropos to consider possible avenues for low-hanging fruit or potentially easy solutions with big upside and low cost.

- Another reasonable approach would be to have the federal government partially fund or shepherd the emergence of bifurcated state systems analogous to the response to the Minerals Management Service (MMS). In the aftermath of the Deepwater Horizon explosion and spill, the Department of Interior (DOI) elected to dissolve the MMS and create a new bureau, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), which later split into two--the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE). The division allowed BOEM to concentrate on policy issues like offshore leasing, resource evaluation, review and administration of oil and gas exploration and development plans, and other environmental policy tasks. The BSEE, on the other hand, will handle enforcement and safety oversight, permitting, inspections and other enforcement related activities. The split has the potential to isolate policy from enforcement, and could enable an environment where industry, rightfully, has the capacity to inform and educate policymakers while remaining separate from enforcement. State agencies such as the Railroad Commission in Texas and TCEQ operate on similar parallel tracks, fostering the necessary collaboration between industry knowledge and oversight while enabling objective review and safety checks on processes.
- In a similar vein, EPA should foster growth of state geological surveys, some of whom handle regulatory issues for resource management within states, and many of whom work with the best information. The Bureau of Economic Geology (BEG) in Texas, for example, is a key reason why the state's oil and gas industry, as well as its oversight, is so strong today. Furthermore, BEG has played a pivotal role in providing hydrogeological data to the state in the form of testimony and research.
- State regulatory authorities should be proactive in demonstrating their autonomy by reviewing and strengthening conflict of interest issues; for example, in Texas, Railroad Commissioners are elected officials. Though recusal rules are in place in event of a conflict, strengthening and review of asset divestitures, blind trust and conflict issues could go far in sending a proactive message.
- Generate funds from industry to pay for data collation and analysis. The tremendous amount of data stored in places like BEG (who houses all the geophysical logs for the Railroad Commission, for example) can be better leveraged by state water planning commissions. Can creative structures be

established through nominal taxes to ensure that research and publication persist?

- Encourage support of organizations like Groundwater Protection Council and STRONGER (the State Review of Oil and Natural Gas Environmental Regulations, which is jointly supported by EPA, DOE and the American Petroleum Institute). These jointly supported, not-for-profit entities foment collaboration between industry and government (a good thing, if handled properly and subject to oversight). Equally, if not more importantly, they offer the public an opportunity to view these contentious issues through third-party intermediaries who can proffer clarity and objectivity.
- Commensurate with the second ninety-day report out of the DOE, insist that states compel producers to "measure and publicly report the composition of water stocks and flow throughout the fracturing and clean-up process." States should also require that listing the source of water throughout the process be a prerequisite.
- Follow the example set by Arkansas and require companies to file pre- and post-completion logs of chemicals planned for use and used in the frac. This is similar to what Texas has enacted in its law.
- Follow up on broader issues of energy-water interrelatedness. As Nicot notes, no recent credible data exists that reflects water intensiveness of our various energy sources: coal, oil and gas, uranium, solar, wind, etc. Put another way, we need comparative analyses of water efficiency to energy content. For its 2014 report, EPA has outlined a number of study goals focusing on broad-ranging concerning fracking issues, such as well integrity during and after a frac, disposal methods and potential pitfalls, and subsurface chemistry changes that could affect transmissivity, among many (figure 3). Interestingly, though, it also appears to forecast the need for water availability studies, and this kind of information could conceivably be very valuable to the states, where water availability issues are highly local. On this last point, Texas could serve as an excellent proxy going forward on how energy production and water are interrelated, and how water availability should drive energy policy. For this reason alone, it is critical that states maintain the flexibility and funding needed to foster the development of resources without sacrificing environmental stewardship.

Chapter Five: Water and Hydraulic Fracturing in Texas: An Overview

5.1 Water use estimates

Water availability for hydraulic fracturing may be a more critical question we need to be asking. Federally-led research is bearing this out. The US Geological Survey (USGS) is currently developing methods in the Bakken Shale in North Dakota to handle the most pressing questions associated with widespread hydraulic fracturing, and they have little to do with contamination. TDS content of source water, how much water can be recycled safely, and when seasonally the water is needed, i.e. mapping demand to fit supply fluctuations, are the most pressing points of inquiry (Engle 2011). Notably, these are largely issues of local concern.

Experts familiar with the Eagle Ford and Barnett Shales in Texas are already concentrating on water availability as the preeminent chokepoint for the state's energy production and long-term water needs. Some would argue that water availability is the key environmental concern to emerge from the fracking boom. These worries have sharpened locally against the backdrop of one of, if not the worst, droughts in recorded history. Growing anecdotal accounts have emerged in local papers, frequently citing individual landowners whose water wells have gone steadily deeper in search of fresh water, as nearby fracking operations increase in scope and number. In 2008, a lack of drilling in the Eagle Ford meant little appreciable water use; the figure was more than 6,000 acre-feet by 2010 and expected to be close to 15,000 acre-feet in 2011 (Nicot presentation). Fracking jobs are widely described as requiring 4-6 million gallons (roughly 12-18 acre-feet) per well in the Eagle Ford (Spruill, Nicot) though some stake that number even higher. That number reflects the water needed for the actual frack, not spudding the well or other stages. To a casual observer, these numbers seem high, but consider that Audubon International estimates the average American golf course uses 312,000 gallons/day, or about 0.95 acre-feet. Variables such as staging crews and equipment, the number of lateral wells drilled, and the number of stages within those laterals varies from well to well or operator to operator, and these variations have profound impacts on water use. Though water-use figures for single wells are not exorbitant, particularly compared to other industries like mining of aggregates or agriculture, there is some concern that on the whole these figures may pose significant challenges. Researchers are looking for ways to measure more widespread impacts. In Texas, where comprehensive records do not exist, one method used by Nicot is to calculate the county area or area of the play and approximate the average spacing between laterals to find total lateral length. Using a rate of intensity (gallons of water per foot of lateral), one divines a raw number that can be modified by qualifiers like recycling figures, number of available rigs, etc. (Nicot 2012). Though inexact, methods such as these have emerged as best credible guesses in the absence of widespread data collection. Recent well counts in the Eagle Ford number one thousand forty active wells, yielding an annual water use of 18 million m^3, equaling roughly 14,600 acre-feet, or $4.76*10^9$ gallons (Nicot 2012). That average yield is roughly 13 million gallons/day over the entire Eagle Ford play at the most recent year's rate of production (Figure 5.1).

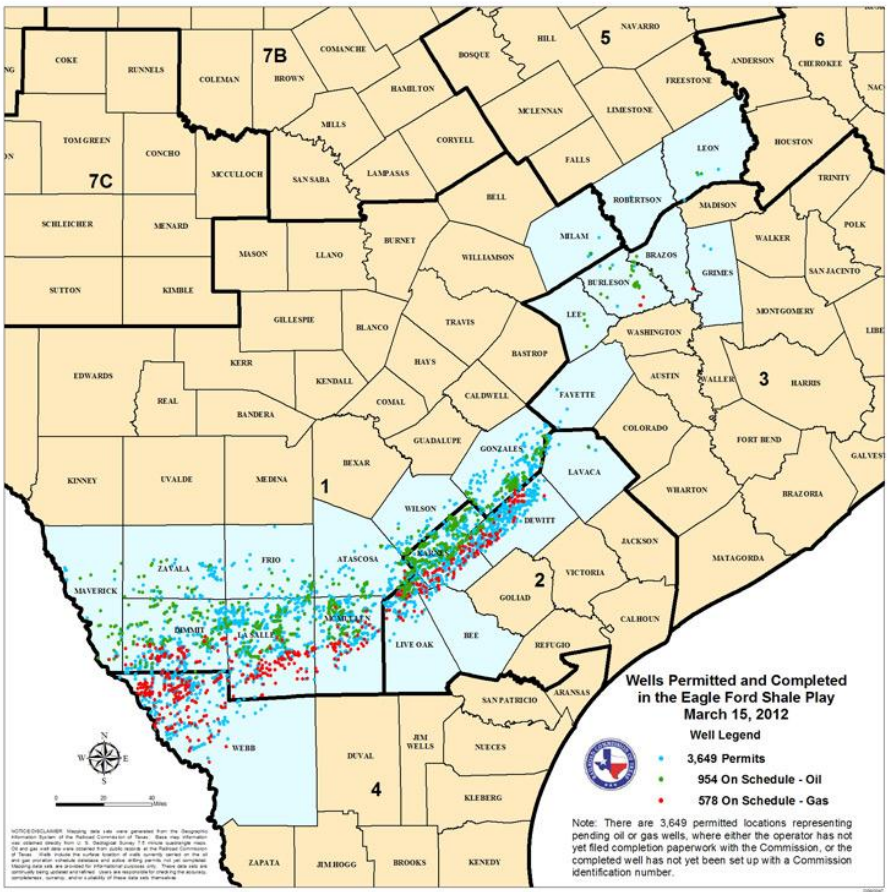


Figure 5.1. Map of wells permitted and completed in the Eagle Ford Shale in Texas as of March 2012, From Railroad Commission Web, http://www.rrc.state.tx.us/eagleford/images/EagleFordShalePlay201203-large.jpg

5. 2 Price effects on exploration

Exploration, and subsequently water use, is dependent on the price of gas; in today's market, exploration will spike and continue with $10/Mcf gas and stall below $5/Mcf gas. In other words, the intensity of exploration is driven by unpredictable externalities (Nicot). In the last year, for example, oil production in Texas was up 6%, while natural gas production dropped down 16% in 2011 because of soft prices (Mills 2012). The number of oil rigs active in the play for the week of March 9, 2012 was 273, an all-time high, while the count for gas rigs was at 72, an all-time low for the region. These numbers, wholly reflective of oil and gas prices, belie the challenge for water managers in forecasting future usage.

5.3 Future Exploration

The Texas Railroad Commission has publicly stated their position that current water supplies are adequate (David Porter's comments Jan 26, 2012) and even taken the position that depressed prices on natural gas will maintain steady downward pressure on the need for water: "the Eagle Ford will change the supply and demand equation (so drastically that) water issues won't materialize because of the impact on supply" (Johnson 2012). This approach seemingly contradicts a simple law of hydrocarbon exploration, namely, that the number of producing wells must always increase to maintain or grow aggregate production, since on the whole output declines over time.

According to Nicot, production in the Eagle Ford will climax in 2024, suggesting that industry's water needs will continue to grow even as water supplies become more and more scarce.

Broadly speaking, it is fair to ascertain that future recovery of natural gas will focus on non-traditional resources; as Daniel Yergin explains in *The Quest*, today's unconventional fuels are tomorrow's conventional resources; that is, there will always be more exploration. Furthermore, markets capitalize on the cheapest production first, meaning that we should expect future production to require increasingly intensive processes, and that includes water. Rex Tillerson of Exxon averred recently that exploration in Poland and in places like China has to date been unresponsive to fracking methods employed. Already, engineers are looking at different fluids, proppants and methods to successfully permeate new formations, experimenting with CO_2, foams and propane, for example (FuelFix Mar 18). Predicting where water use rates will go is exceptionally fraught with uncertainty. Just as water intensiveness of production may rise, it is held in check, by the price of gas, technology breakthroughs, competition for resources, cost of production increases and other factors. Nevertheless, increased production in these harder-to-produce formations will likely require new resources.

5.3.1 Water Recycling and High TDS Water

Efforts are underway to improve water recycling methods. Numbers on reuse improvements vary dramatically, ranging from 30% over a twelve-month period

(Moorhead 2011) to claims of 100% (Ely 2012). The meaning of these numbers is unclear, and without context lacks significant thrust to suggest anything truly substantive. One issue is that producers and regulators are too lax or imprecise when it comes to water origins, and freshwater, brackish water and saline groundwater all offer dramatically different value. The use of brackish groundwater is on the rise, and calls for use of increasingly saline groundwater—water that could not otherwise be used for beneficial use at today's price point—are increasing (Figure 5.3). Technology will continue to search for ways to create systems that are resistant to high TDS without an appreciable decline in efficiency.

Figure 5.3. Retention pond for brackish groundwater pumped from a water well at EOG Resources. The pond holds roughly 40 acre-feet of water—enough to frack roughly three wells--that will be pumped into trucks for use at the wellpad. The poly liner will create an impermeable barrier to contain the brackish groundwater. Photo by author.

Some producers have complained that use of higher TDS waters in frack gel involves a less-than-optimal effect on the proppant, and thus reduces the effectiveness of the frack (Moorhead 2011), others cite the growing trend offshore in using seawater (TDS 30,000-40,000 ppm) for fracking, which indicates that industry is learning quite quickly how to make use of potential resources, irrespective of the challenges (Holditch 2012). This trend may also reveal an unfortunate fact: that when low-cost water remains readily available, industry will use it—until forced otherwise.

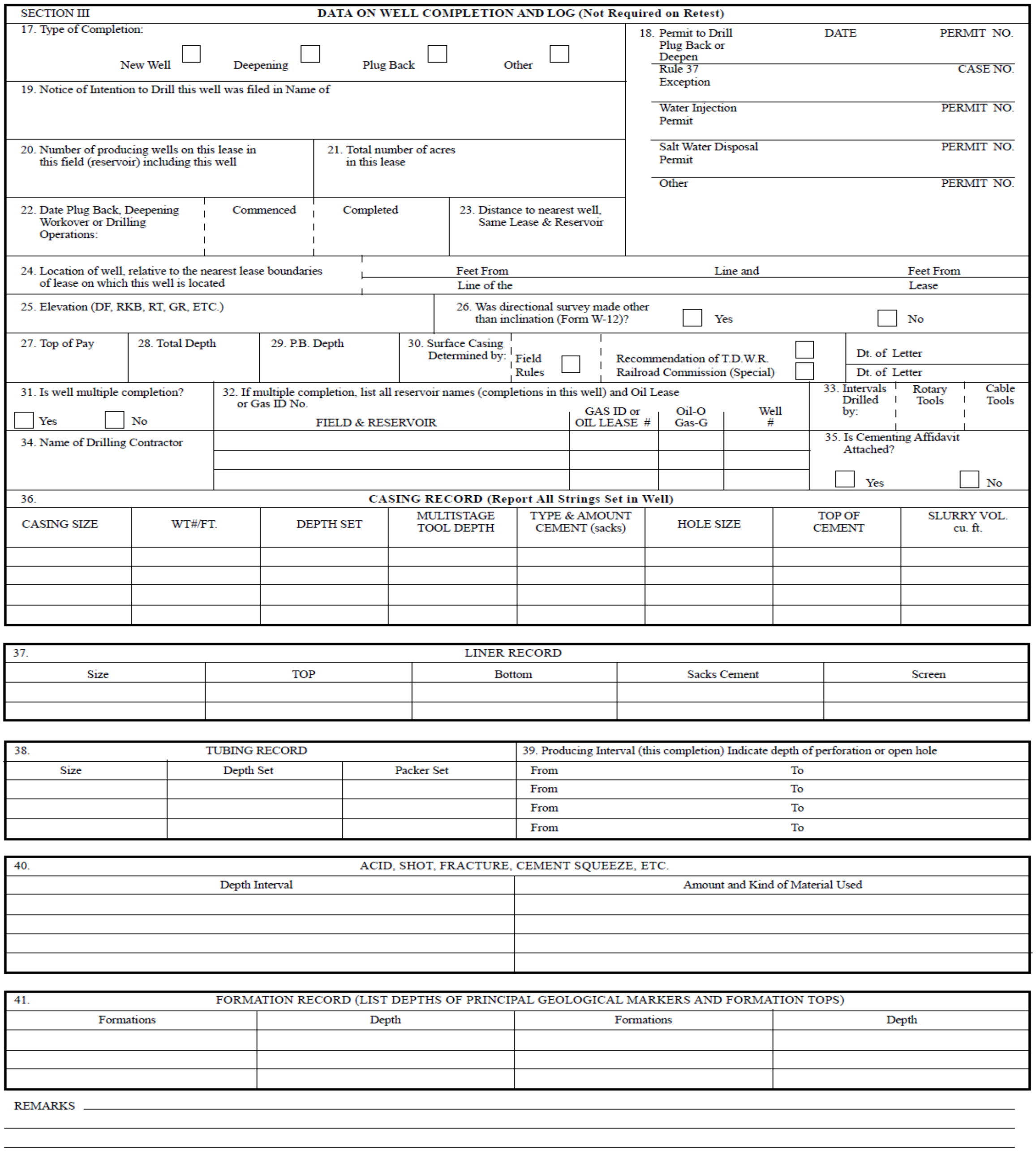
5.4 Texas Groundwater Conservation Districts

Texas' existing case law and regulation is ill-equipped to handle the conflicts arising from water demand in the oil and gas industry and beyond. The indirect effects of legal water groundwater pumping, for example, suggest difficult claims for landowners whose wells must be drilled ever-deeper to keep apace with drawdown or the possibility that over pumping could lead to saltwater or chemical intrusion. The recent Texas Supreme Court ruling in the Edwards Aquifer Authority v. Day/McDaniel case reinforced the strength of landowner's claims to groundwater rights, making these projections even more difficult. At the time of writing, the perceived weakening/leavening of a groundwater conservation district's (GCD) capacity to regulate pumping, thereby potentially infringing on an owner's groundwater rights, has cast the future potency of GCD permitting structures themselves in doubt. Moreover, GCDs across the state enjoy vastly variable levels of funding. Most are ill-equipped to deal with rigorous permitting or regulatory regimes, and observers point out that the recent ruling puts them at even greater disadvantage in litigation matters, as they will be ill-equipped to withstand any taking claims, particularly from seemingly well-funded interests like oil and gas (Brown 2012). Though the RRC requires that water volumes associated with fracking must be disclosed, water for oil and gas exploration is exempt from pumping constraints levied by the GCDs in Texas according to Texas Water Code section 36.117 (Texas RRC web). Whether fracking will be subject to those same pumping constraints is a question of legal and regulatory uncertainty, and some GCDs are permitting unlimited withdrawals for fracking, despite the uncertain language (Brown 2012). As long as the language remains unclear, it seems that the specter of litigation will be a formidable deterrent to any ambitious GCD aiming to control pumping.

Furthermore, these GCDs may be staffed or controlled by local stakeholders whose mineral rights or landholdings make it difficult to balance the conflict of interest in negotiating local water availability needs with potential personal windfalls generated by the minerals they hold. This combination of regulatory impotency, lack of funds and potential conflict suggests that withdrawal issues will be under- or improperly regulated in the near term and suggest a more viable long-term solution, perhaps at the Groundwater Management Area (GMA) level or higher at the Texas Commission on Environmental Quality (TCEQ).

5.5 Railroad Commission Disclosure Recommendations

For this reason, the Texas RRC can and should once again assert its leadership in the field. Disclosure forms like the G-1, which are filed at completion, should include precise volume figures, and groundwater and surface water splits and TDS levels (figure 5.5).



SECTION III — DATA ON WELL COMPLETION AND LOG (Not Required on Retest)

17. Type of Completion: New Well ☐ Deepening ☐ Plug Back ☐ Other ☐

18. Permit to Drill Plug Back or Deepen — DATE — PERMIT NO.
Rule 37 Exception — CASE NO.
Water Injection Permit — PERMIT NO.
Salt Water Disposal Permit — PERMIT NO.
Other — PERMIT NO.

19. Notice of Intention to Drill this well was filed in Name of

20. Number of producing wells on this lease in this field (reservoir) including this well

21. Total number of acres in this lease

22. Date Plug Back, Deepening Workover or Drilling Operations: Commenced | Completed

23. Distance to nearest well, Same Lease & Reservoir

24. Location of well, relative to the nearest lease boundaries of lease on which this well is located — Feet From Line of the — Line and — Feet From Lease

25. Elevation (DF, RKB, RT, GR, ETC.)

26. Was directional survey made other than inclination (Form W-12)? ☐ Yes ☐ No

27. Top of Pay | 28. Total Depth | 29. P.B. Depth | 30. Surface Casing Determined by: Field Rules ☐ | Recommendation of T.D.W.R. ☐ Dt. of Letter | Railroad Commission (Special) ☐ Dt. of Letter

31. Is well multiple completion? ☐ Yes ☐ No

32. If multiple completion, list all reservoir names (completions in this well) and Oil Lease or Gas ID No.

FIELD & RESERVOIR	GAS ID or OIL LEASE #	Oil-O Gas-G	Well #

33. Intervals Drilled by: Rotary Tools | Cable Tools

34. Name of Drilling Contractor

35. Is Cementing Affidavit Attached? ☐ Yes ☐ No

36. CASING RECORD (Report All Strings Set in Well)

CASING SIZE	WT#/FT.	DEPTH SET	MULTISTAGE TOOL DEPTH	TYPE & AMOUNT CEMENT (sacks)	HOLE SIZE	TOP OF CEMENT	SLURRY VOL. cu. ft.

37. LINER RECORD

Size	TOP	Bottom	Sacks Cement	Screen

38. TUBING RECORD

Size	Depth Set	Packer Set

39. Producing Interval (this completion) Indicate depth of perforation or open hole

From	To
From	To
From	To
From	To

40. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

Depth Interval	Amount and Kind of Material Used

41. FORMATION RECORD (LIST DEPTHS OF PRINCIPAL GEOLOGICAL MARKERS AND FORMATION TOPS)

Formations	Depth	Formations	Depth

REMARKS

Figure 5.5: Page two of Form G-1, required by Texas RRC at well completion. From RRC Web, http://www.rrc.state.tx.us/forms/forms/og/pdf/g-1p.pdf

It should also encourage fracfocus.org to do same, listing surface water and groundwater splits, precise source and TDS. RRC should look for creative ways to compel producers to use brackish and saline water, whether through statute, tax incentives or collaboration with local stakeholders. The speed with which it maps well data on www.fracfocus.org has also been criticized as too slow for local landowners to file protest; to countermand these criticisms it should improve outreach and expedite postings (Hargrove 2012).

Chapter Six: Conclusions

On Saturday, April 28, the director of EPA's Region Six, Al Armendariz, formally resigned his post effective April 30, 2012, in the wake of reports in which he used the word "crucify" to describe his approach to dealing with violators of environmental law (Cappiello 2012). As the director of the region that oversaw the Range emergency order, Armendariz had drawn ire from pro-drilling advocates who viewed his directorship as overly politicized and ideologically driven. The resignation was likely viewed from within EPA as a needed precaution against drawing additional criticism from domestic energy advocates during an election year. In other words, it was considered a political maneuver to prevent further debasement of the national EPA at the expense of an unpopular local director. The episode underscores the challenges ahead for industry and EPA. The politics surrounding hydraulic fracturing have obfuscated the scientific data from the outset, and will continue to do so if EPA, industry and state regulators do not collaborate. Industry and regulators must focus on science-based regulation and abandon sovereignty battles and zealotry to refocus on how best to address oversight and how to regain the public trust, which has been lost. "Macro" issues, such as shepherding the emergence of robust EPA-approved state regulatory regimes, fostering applied research, and restoring public faith in the public-private dynamic should be a focus. The emergence of internet tools and public databases can usher in greater transparency for regulators, provided data is collated and analyzed in meaningful ways. Here, state geological surveys, water development boards and other agencies can offer critical insight into future challenges. States should prioritize funding these kinds of engagements, and EPA can play a role in encouraging those initiatives. Lastly, EPA, the states and industry should welcome the continued prominence of objective, empirically-driven organizations like Groundwater Protection Council, who have established a history of working within the federalist model of environmental sovereignty. Lastly, and most controllably, all sides should take pains to depoliticize the issues for the sake of cogent and enforceable policy.

References

Bloomberg, US Shale bubble inflates after near record prices for untested fields, January 9, 2012, Bloomberg, http://www.bloomberg.com/news/2012-01-09/shale-bubble-inflates-on-near-record-prices-for-untested-fields.html (Accessed January 9, 2012).

Brown, B., 2012, Impacts of shale-gas development on water resources, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Buchele, M., December 16, 2011 "Fracking Report Riverberates(sic) in Texas," KUT Radio, On-air report.

Burnett, D., 200?, Global petroleum Institute, Texas Water Resources Institute, Texas A&M University, 11 pp.

Capiello, D., 2012, Top EPA official resigns over 'crucify' comment, April 30, 2012, The Associated Press, http://www.google.com/hostednews/ap/article/ALeqM5h0EL9BggtQJBtCpo240SZULMIUHg?docId=4f484f9491ed489e95d443a9c416b94b (Accessed April 30, 3012)

Collier, H., 2012, Groundwater resources: what to expect when you are expecting shale-gas development in your area, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Detrow, S., August 12, 2011, "How Pennyslvania's Fracking Chemical Disclosure Rules Stack Up Against Other States," State Impact, Online Publication, http://stateimpact.npr.org/pennsylvania/2011/08/12/whats-in-the-frack-how-pennsylvanias-chemical-disclosure-rules-stack-up-against-other-states/ Last accessed November 27, 2011.

Ely, J., 2012, Game changing technology for treating and recycling frac water, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Energy Information Administration, 2011, Annual Energy Outlook 2011 Early Release Overview, Energy Information Administration, US Department of Energy, Washington D.C., http://www.eia.gov/forecasts/aeo/ Last accessed February 20, 2012.

Engle, R., 2012, USGS Position on emerging challenges in hydraulic fracturing, interview with author, USGS El Paso. Feb 2, 2012.

EPA Region Six website. http://www.epa.gov/aboutepa/region6.html. Last updated December 13, 2011. Last accessed December 8, 2011.

EPA Web, About EPA: What we do, www.epa.gov/aboutepa/whatwedo.html. Accessed February 6, 2012.

EPA Web, Guidance for the Determination of Underground Sources of Drinking Water, http://www.epa.gov/r5water/uic/r5guid/r5_03.htm, Accessed April 28, 2012.

EPA Web, Oil and Natural Gas Air Pollution Standards, http://www.epa.gov/airquality/oilandgas/, accessed April 29, 2012.

EPA Web, Underground Injection Control, UIC Program Primacy, http://water.epa.gov/type/groundwater/uic/Primacy.cfm, last updated March 6, 2012, last accessed March 25, 2012.

EPA Web, Hydraulic Fracturing Background Information, http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydrowhat.cfm, last updated March 23, 2012, last accessed April 21, 2012.

FY2013 OECA NPM Guidance, EPA Office of Enforcement and Compliance Assurance (OECA) http://www.epa.gov/planandbudget/annualplan/FY13_OECA_DraftNPMGdnce.pdf, last accessed April 5, 2012.

EPA, Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals From Electric Utilities; Proposed Rule, 75 Fed. Reg. 35,128, June 21, 2010, found at http://www.environmentalintegrity.org/documents/EarthjusticeNRDCetalCCRcommentsFINAL.pdf, last accessed April 25, 2012.

Fisher, K., 2012, Hydraulic fracturing safety from a rocks mechanics and fluid chemistry perspective, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Fracking Update: What States are doing to ensure safe natural gas extraction, Updated July 2011, National Conference of State Legislatures, Accessed January 24, 2012, http://www.ncsl.org/issues-research/energyhome/fracking-update-what-states-are-doing.aspx

FuelFix: Houston Chronicle Energy Blog, 2012, Democrats say federal drilling oversight is lax, Posted February 8, 2012 from Associated Press,http://fuelfix.com/blog/2012/02/08/democrats-say-federal-drilling-oversight-is-lax/ (Accessed February 8, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, Fracking failing to crack China, Europe shale, Exxon says, Posted March 9, 2012 from Bloomberg, http://fuelfix.com/blog/2012/03/09/fracking-failing-to-crack-china-europe-shale-exxon-says/, Accessed March 18, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, Industry attacks leaked draft of fracking fluid rule, Posted February 6, 2012, http://fuelfix.com/blog/2012/02/06/industry-attacks-leaked-draft-of-fracking-fluid-rule/, (Accessed February 8, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, Parched Texans impose water-use limits for fracking gas wells, Posted October 22, 2011 from Bloomberg News, http://fuelfix.com/blog/2011/10/06/parched-texans-impose-water-use-limits-for-fracking-gas-wells/, (Accessed February 8, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, Shareholders want more risk transparency disclosures for hydraulic fracturing, Fuel Fix Blog, Houston Chronicle, Posted February 8, 2012, http://fuelfix.com/blog/2012/02/08/shareholders-want-more-risk-transparency-disclosures-for-hydraulic-fracturing/, Accessed February 8, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, Geoscientists call for honest dialogue on fracking, Posted February 8, 2012 from AP, http://fuelfix.com/blog/2012/02/08/geoscientists-call-for-honest-dialogue-on-fracking/, (Accessed February 8, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, Smith, J., January 19, 2012, Natural gas in Parker County water wells not from Barnett Shale, driller says, Posted January 19, 2012, Fort-Worth Star-Telegram, http://www.star-telegram.com/2011/01/18/2778239/natural-gas-in-parker-county-water.html(Accessed January 20, 2012).

FuelFix: Houston Chronicle Energy Blog, 2012, EPA seeking peer reviewers for Pavillion fracturing study, Posted January 13, 2012, http://fuelfix.com/blog/2012/01/13/epa-seeking-peer-reviewers-for-controversial-pavillion-fracking-study/ (accessed January 13, 2012).

Groat C., Grimshaw T., 2012, Fact-Based Regulation for Environmental Protection in Shale-Gas Development, Report for the Energy Institute at the University of Texas at Austin, http://energy.utexas.edu/.

Groundwater Management, Railroad Commission of Texas, 2012, Website, http://www.rrc.state.tx.us/environmental/environsupport/groundwatermgnt.php, last accessed March 20, 2012.

Henry, T., December 13, 2011, "How the How the Natural Gas Industry Is Responding to the EPA Fracking Contamination Report" State Impact, Online Publication, http://stateimpact.npr.org/texas/2011/12/13/industry-responds-to-epa-fracking-contamination-report/#more-3104, (Accessed December 16, 2011).

Hargrove, B., 2012, How One Man's Flaming Water Fired Up a Battle Between Texas and the EPA, Dallas Observer News, posted April 26, 2012, http://www.dallasobserver.com/2012-04-26/news/fire-in-the-hole/5/.

Harvey S. et al, 2012, Leaking Profits: The US oil and gas industry can reduce pollution, conserve resources, and make money by preventing methane waste, Prepared for National Resources Defense Council, p. 1-68, http://www.nrdc.org/energy/files/Leaking-Profits-Report.pdf.

Holditch, S., 2012, Pertinent issues in hydraulic fracturing, interview with author, February 13, 2012.

Huque, A.S., Watton, N., 2010, Federalism and the Implementation of Environmental Policy: Changing Trends in Canada and the United States, Public Organization Review, 10:71-88.

Johnson, D., 2012, Regulations and Permits for Shale-Gas development and production, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Kreitler, C., 2012, Lessons learned from the Barnett shale, range resources litigation, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Konisky, D., 2009, The Limited Effects of Federal Environmental Justice Policy on State Enforcement, The Policy Studies Journal, V. 37, no.3 p 475-496.

Loyola, M., 2011, Trojan Horse: Federal manipulation of state governments and the Supreme Court's Emerging Doctrine of Federalism, Texas Review of Law and Politics, 1:113-153.

Mace, R., 2011, TWDB, Water availability issues associated with hydraulic fracturing, interview with author, September 6, 2011.

Mills, A., 2012, The economic importance of the Texas Shale-gas Industry, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Moorhead, S., Site visit to EOG Resources well pads in the Evergreen Underground Water District, December 6, 2011.

Nicot, J.P. et al, Bureau of Economic Geology, June 2011 "Current and Projected Water Use in the Texas Mining and Oil and Gas Industry," Prepared for Texas Water Development Board.

Nicot, J.P., 2011, BEG, Discussion of Water needs for hydraulic fracturing, interview with author, October 10, 2011.

Nicot, JP, Scanlon, B., March 2012, Water Use for Shale-Gas Production in Texas, US, Environmental Science and Technology, working manuscript "just accepted", citable by the Digital Object Identifer.

Oates, W.E., 2001, A reconsideration of environmental federalism, Discussion paper 01-54, Resources for the future, www.rff.org.

Oneacre, J., 2012, Gas origins: diagnostic environmental parameters used in shale-gas/groundwater studies, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Powers, E.C. , 2011, Fracking and Federalism: Support for an Adaptive Approach that Avoids the Regulatory Tragedy of the Commons: Journal of Law and Policy, v.19 p. 913-971.

Rahm, D., 2011, Regulating hydraulic fracturing in shale gas plays: the case of Texas: Energy Policy, v.39 p 2974-2981.

Railroad Commission of Texas, 2012, Regulations of Groundwater Conservation Districts, http://www.rrc.state.tx.us/barnettshale/wateruse.php, last accessed April 7, 2012.

Regulation of Hydraulic Fracturing Under the Safe Drinking Water Act, Last updated December 7, 2011, http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydroreg.cfm (Last accessed December 11, 2011).

Riley, J., 2011, Discussion of United States v. Range Prod. Co. et al., No 3:11-CV-00116 (N.D. Tex, Jan 18, 2011), Interview with author, November 15, 2011.

Schlacter, B. 2012, EPA drops action against Range Resources over Parker County water wells, Ft. Worth Star-Telegram, online version, www.star-telegram.com/2012/03/30/3849362/epa-drops-action-against-range.html#storylink=cpy, accessed April 1, 2012.

Secretary of Energy Advisory Board, August 11, 2011, "The SEAB Shale Gas Production Subcommittee Ninety-Day Report" US Department of Energy.

Secretary of Energy Advisory Board, November 18, 2011,"The SEAB Shale Gas Production Subcommittee Second Ninety-Day Report" US Department of Energy.

Serebrin, H., 2011, EPA Initiates Proposed Rulemaking Process to Obtain Fracking Fluid Data, Posted December 6, 2011,

(http://greenmien.knowledgemosaic.com/2011/12/06/epa-initiates-proposed-rulemaking-process-to-obtain-fracking-fluid-data/), Blog site, last accessed April 5, 2012.

Spruill, R., October 15, 2011, "Water Availability, not Contamination, Worries Residents Above Eagle Ford Shale," Corpus Christi Caller, Online version. Accessed October 17, 2011.

Stokley, C.O., 2012, Shale-gas developments and the potential impact (good and bad) on the environment, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Stone, A., 2012, Public perceptions and mis-perceptions of shale-gas development impacts on the environment and water-supply integrity, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Waxman Committee Report 2011, Chemicals Used in Hydraulic Fracturing, US House of Representatives, Committee on Energy and Commerce, 2011, Prepared by Minority staff, http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf, accessed April 5, 2012.

Wallace, D., 2012, Rural water supply perspective on the positive impacts of oil and gas development, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Weber, A., 2012, Oil and Gas Industry regulatory compliance: many companies go above and beyond, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Weinberg, D., 2012, Citizen concerns related to shale-gas development and production in Texas, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.

Welborn, D. 1988, Conjoint federalism and environmental regulation in the United States, Publius vol 18 no. 1 27-43.

Williamson, K., 2012, Facing Frack hysteria: Pa. drilling is cleaner than ever, New York Post, Posted February 8, 2012, http://www.nypost.com/p/news/opinion/opedcolumnists/facing_frack_hysteria_PWwcCDKjR1BxHCVNDT7ARO, last accessed March 25, 2012.

Yergin, D., 2011, The Quest: Energy, Security, and the Remaking of the Modern World, Penguin Press, New York, New York.

Young, M., 2012, Above-ground energy/water aspects of unconventional gas and hydrofracking, *in* Proceeding, American Groundwater Trust and American Institute of Professional Geologists Information exchange symposium on Shale-gas Development and water issues, Austin, March 2012.